Burnishing is the polishing of a surface by sliding contact with another smooth, harder metallic surface. Usually there is no displacement or removal of metal. Burnishing is probably the least serious of friction-caused problems; however, it should be very closely monitored. In can be considered a warning of an impending more serious condition—galling, which is discussed later.

Chafing is the wear between two parts caused by the rubbing, sliding, or bumping of one on the other. The term is normally used to describe wear between parts not normally in contact. Chafed fabric, wood, or metal can be detected easily since chafing usually marks one or both parts involved. Metal parts, when chafed, show a bright area where contact has been made. Aluminum parts normally display a black or dark gray residue around the point of chafing. The simplest method of inspecting for chafing is to carefully inspect cables, wires, tubes, etc., wherever they are in close proximity to another part or when they are mounted to permit motion.

Cutting results in cuts or grooves in the worn part. The cause of cutting is similar to chafing except that a sharp edge is in contact, instead of a smooth surface.

Dent is an indentation in a surface produced by an object striking with force. The areas surrounding the indentation will usually be slightly upset. Areas especially susceptible to dent damage are the propeller, spinner, nose contour of engine cowling, nose cone of fuselage, and the leading edges of wings, horizontal and vertical stabilizers.

Elongation is the term used to describe the egg-shaped wear of a bearing surface around a bolt, hinge pin, clevis pin, etc. It results in looseness in one plane of motion greater than that of the other planes. Flight control surface hinges, engine control rod ends, flight control push-pull rod ends, bellcrank ends, cable clevis ends, and similar parts are particularly susceptible to this type of wear.

For example, an elevator may have the control cable rigged so taut that a positive pressure is applied on one side of the hinge. During normal operation, the hinge bearing will wear egg-shaped due to the hinge pin rotating under a thrust load imposed by the cable.

Erosion is the loss of metal from the surface by mechanical action of foreign materials, such as fine sand or water. The eroded area will be rough and may be lined in the direction in which the foreign material moved relative to the surface. Aircraft operated from unimproved airports are particularly susceptible to erosion, primarily on propellers, landing gear, cowling, and leading edges of wings and stabilizers.

Galling is the breakdown (or buildup) of metal surface due to excessive friction between two parts having relative motion. Particles of the softer metal are torn loose and "welded" to the harder metal. Galling quite often begins as burnishing.

Gouge. A gouge usually involves material loss but may be largely the displacement of material and results from contact with foreign material under heavy pressure.

Scratch. A slight tear or break in material surface from light momentary contact with foreign material or object.

Score is a deeper (than scratch) tear or break in metal surface from contact under pressure. It may show discoloration from the temperature produced by friction. The term is normally used to describe conditions on parts designed to run together; i.e., a worn bearing might score the shaft.

Tear is a discontinuity which has progressed through the full thickness of the material.

Overload.

Aircraft are designed to absorb the loads imposed during normal operation and accept a certain amount of overload. Excessive loads, however, result in failure or deformation of the structure. This deformation may be slight or prominent, but it is usually visible. In any case, it can be detected and classified by certain appearances peculiar to the type of overload applied.

In the majority of cases, loads which result in deformed parts also overload the adjacent structure. Because of the possibility of hidden damage, a qualified mechanic, repair station, or the aircraft manufacturer should be called upon to make a detailed inspection when deformation is noted. This is especially true when an aircraft has been in an accident or subjected to suspected overloads on the structure.

Types of forces.

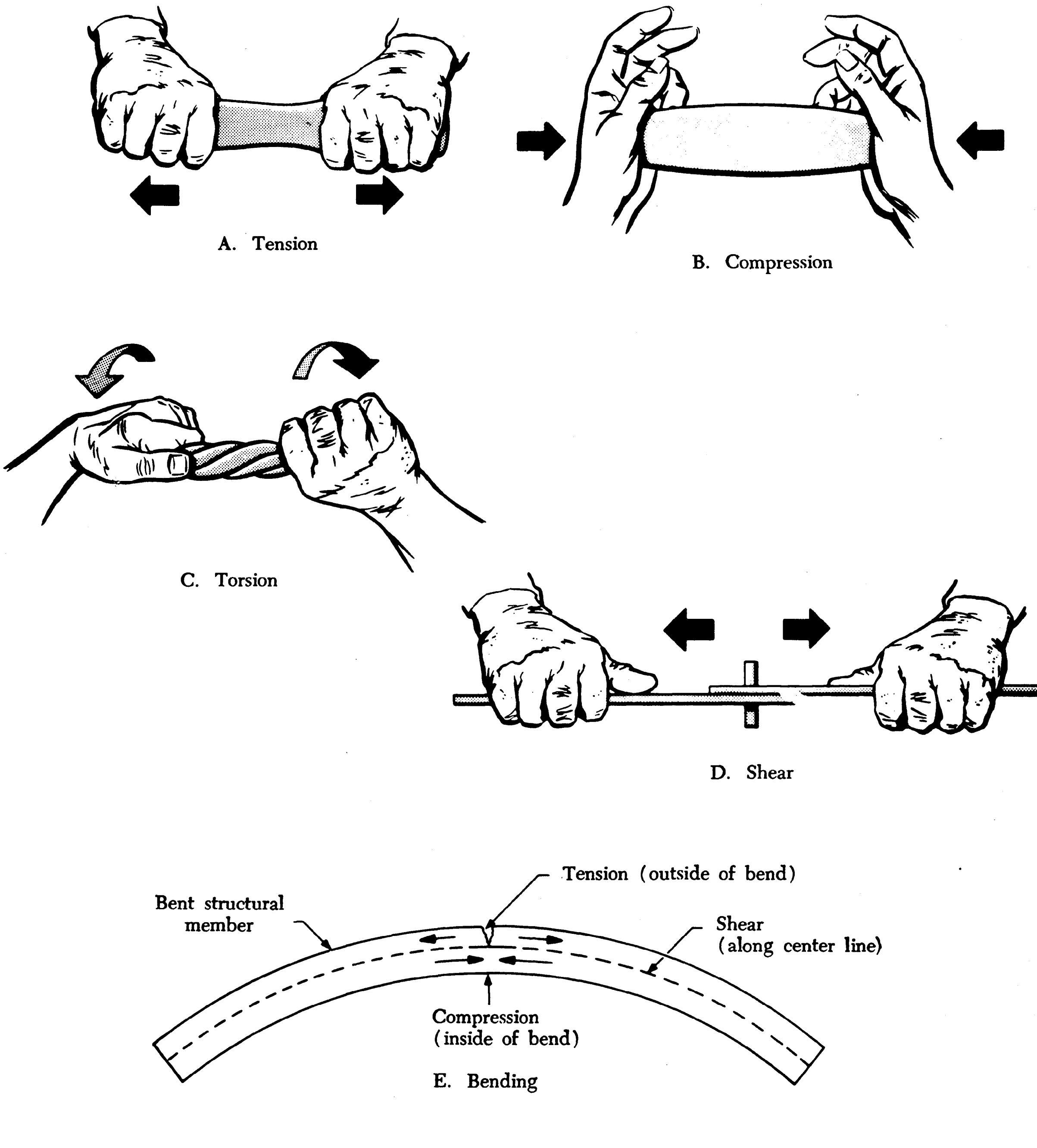

FIGURE I-1. Five stresses acting on aircraft.

Tension. When a load is applied at either or both ends of an item, tending to pull it apart, it is loaded in tension. Overloads due to tension usually occur after a hard landing, taxiing on a rough field, or during flight in very turbulent air. After a hard landing, all attachment fittings should be examined for tension failures or deformation. Failure is indicated by attachment fittings which show signs of pulling away from fuselage structure or failure in a welded area, and bolt holes which are elongated or torn. Welds are particularly subject to failure under tension loads and should be closely inspected.

In aircraft of all metal construction, overloads are usually evidenced by wrinkling of the metal skin, around wing, stabilizer and landing gear attachment points, and deformed or cracked fittings.

Wing struts are in tension during normal flight conditions and when severe vertical currents or gusts are encountered, they may be subjected to heavy loading. The strut attachment points, at the wings and fuselage, should be carefully examined for the indications of failure described for landing gears.

Compression. A part subject to compression loads tends to fail (bulge) at the weakest point in overall length or span, at right angles to the application of the overload.

Compression failures are usually found after a hard landing, flight through turbulent air, or an accident, and affects the same areas referenced under tension in the previous paragraphs. A bulge is indicative of compression failure; however, it is not always noticeable. In this event, a break in protective paint coating may be present. Sheet metal and extruded members will show some form of distortion when damaged by compression. In long members such as wing struts, compression may be first evidenced by what appears to be a bow or bend in the member.

A compression overload of a wood member can usually be detected by a slight ridge across the face of the member at right angles to the direction of the grain.

Torsion is a twisting force that tends to turn one end of a part about a longitudinal axis while the other end is held fast or turned in an opposite direction. Wheels caught in frozen ruts during a landing will tend to twist the landing gear members. Severe air loads imposed during abnormal flight maneuvers or flight through turbulent air may twist the control surfaces or other components. Improper rigging adjustments to wings and tail surfaces may also cause twisting of these components. The inspection, in these cases, is similar to that described for tension and compression overloads.

Certain landing gears employ a torsional member referred to as a "scissor," "nut cracker," or "torque link." Careful inspection should be made of this assembly for loose bolts and cracks, especially after landing in a rough or rutted field.

Shear. An action or stress resulting from forces applied so as to cause a portion of a part to move relatively to another portion in a direction parallel to the direction of the force. This action is normally found in tools such as bolt cutters or sheet metal shears which apply the force and shear the material being worked.

When an overload is applied, the part having the least resistance to the force will be the first to fail. For this reason, bolts, rivets, and clevis pins should be examined for signs of failure. This is especially important when it is found that the overloaded members do not show the usual indications of failure. Failed bolts, clevis pins, and rivets may shear or partially shear and yet appear perfectly normal to the casual observer. To check for this condition, the following hints may prove useful:

1—*Bolts and Clevis Pins*—Removal and inspection is a positive check for condition. Removal of bolts, clevis pins, etc., is especially difficult if deformed or otherwise damaged by excessive shear loads.

2—*Rivets*—Loose or sheared aluminum rivets may be identified by the presence of black oxide which is caused to form rapidly by working of the rivet in its hole. This oxide will seep out from under the rivet head to stain the surrounding surface. Pressure applied to the skin adjacent to the rivet head will help verify the loosened condition of a rivet.

Bending is a force or combination of forces that will cause a rigid member to curve or bow away from a straight line. Overloads which cause bending are usually the result of abnormal landing and flight loads, or improper ground handling of the aircraft. Bent components will result from the following practices: stepping or pushing on lift or other struts; lifting the aircraft by the stabilizer; jacking or placing supports under longerons; overloading cabin or baggage compartments; or exceeding turn limitations of the nose steering mechanism. On fabric-covered airplanes, a bent member can often be detected by looseness or wrinkling of the fabric. Wood or metal skin may become wrinkled, cracked, or distorted.

Heat.

The principal source of heat affecting the aircraft is the powerplant. From the standpoint of inspection, we are interested in two heating methods, direct and indirect, both normally the result of engine operation. Direct heat normally originates from leaking exhaust gases. Indirect heat is that radiated from any hot system or component.

Direct heat. Leaks in components of the exhaust system may permit carbon monoxide to enter the cabin heating system. More severe leaks or failures of exhaust system components may allow the escape of flames into surrounding areas with disastrous results.

To forestall serious hazards, the exhaust pipes, clamps, bolts, braces, and welds should be examined at frequent intervals. Exhaust gaskets must be in good condition. The nuts holding the exhaust pipe or manifold to the cylinder must be properly torqued and safetied. Loose exhaust pipe bracing allows the pipe to vibrate, causes failure at the welds, and leaks from the flange surfaces. Heater muffs or shrouds should be removed to allow inspection of the exhaust system components.

Indirect Heat. Indirect heat radiated or conducted from the engine is carried off by the action of the air stream passing through the cowling. If the air stream is unable to carry the heat away, the resulting high temperatures are harmful to the engine and may cause failure of accessories or other parts of the powerplant assembly. Excessive indirect heat may be indicated by one or more of the following:

1—High oil temperature.

2—High cylinder head temperature.

3—Blistering of the paint covering adjacent parts within the engine compartment.

4—An odor of burned oil or hot rubber during or after engine operation.

5—Auto-ignition upon shut down of the engine (engine tries to continue functioning).

If any of the above indications are observed, immediate steps should be taken to trace the trouble to its source, which is usually loose or leaking engine baffles, improperly fitted cowling, improper rigging of carburetor heat door control, dirty oil coolers and screens, improper grade of oil, or oil leaks. In any case, once indications of excessive heat are found, a detailed inspection should be made by an appropriately rated mechanic or repair station and corrective action taken immediately.

Vibration

Vibration is the source of many malfunctions and defects that occur throughout the life of the aircraft. Not only will vibration affect parts that are loose or poorly installed, but it will also accelerate wear and cause the ultimate failure of others. There are two types of vibration in aircraft operation; low frequency and high frequency.

Low Frequency (usually noticeable vibration). Low frequency vibration is usually caused by a malfunctioning powerplant or propeller, worn engine mounting pads, looseness of the aircraft structure, or improper rigging. The problem causing vibration should be corrected as soon as discovered since it will cause abnormal wear between moving parts of the aircraft and may induce failure in any number of other aircraft parts.

High Frequency (less noticeable vibration). High frequency vibration is caused by inherent vibration characteristics of the rotating masses in the engine and propeller. It can also be caused by aerodynamic forces acting through the propeller or by engine firing impulses. High frequency vibrations are usually charted by special instruments at the time the aircraft is type-certificated by the FAA. When harmful vibration frequencies are found, placards are installed indicating the engine operating ranges which must be avoided.

Factors of Vibration Damage. The factors of vibration damage can be grouped into three categories: fatigue, excessive clearance, and poor installation. These points should be considered when inspecting for the effects of vibration.

Fatigue. Fatigue is the weakening and/or eventual failure of a member due to the cumulative effects of repetitive loads which cause a change in the molecular structure of the part. Fatigue itself cannot be detected or measured while it is taking place except, possibly, under laboratory conditions. Its effects are usually made known by the ultimate failure of a part. The best prevention against fatigue damage is to maintain a smoothly running powerplant. In addition, control excessive or abnormal looseness in other components of the aircraft by good maintenance practices, particularly engine mounting pads which are designed to isolate and absorb vibration.

With the above in mind, it is easily understood why the various components must be properly mounted and secured to resist the damaging effects of vibration. Copper lines are especially susceptible to fatigue and become hard and brittle when subjected to vibration. The lines should be periodically replaced or removed and annealed to restore the original softness.

Excessive Clearance. Excessive clearances accelerate the wear rates of all components in which they exist and can contribute to the initiation of flutter. Flutter is an aerodynamic function, wherein oscillating high loads are imposed on the affected movable surfaces and can result in rapid fatigue failure of critical areas, such as control surface hinge fittings and attachments. Wear rates are extremely high during flutter. It is very important to maintain clearance within the limit established by the manufacturer.

Installation.

Installation, as it is used here, is the proper arrangement of the various parts in relation to each other. A fuel line, for example, may have sufficient clearance relative to another part while at rest, yet under vibration, it may move and make contact with the other part and become chafed or cut.

Ignition or electrical cables in contact with each other may appear perfectly rigid during normal operation, but during periods of vibration they may rub together and wear through the protective casings. Every part of the aircraft should be carefully examined for signs of chafing or cutting. If vibration has gone uncorrected for a time, all nuts, bolts, clamps, etc., should be checked for proper security.

Propeller Vibration

Propellers have inherent vibration characteristics which are not usually harmful but can induce fatigue and in time cause failure of parts essential to the airworthiness of the aircraft. This is one reason why periodic inspection of the aircraft is essential.

A special word about propellers. Quite often a propeller blade becomes nicked, especially at the leading edges. These nicks become points of stress concentration. IT IS IMPORTANT THAT NICKS BE REMOVED AS SOON AS POSSIBLE AND IN A PROPER MANNER. Since the removal of nicks requires special skills and tools and a thorough knowledge of the procedure, such work may be accomplished by certificated personnel only. The importance of correct removal of even small nicks AS SOON AS POSSIBLE after incurring them, cannot be overstressed.

Section 4. INSPECTION DO'S AND DON'TS

DO'S

DO have an assortment of proper tools for inspection.

DO have an inspection check form and a regular inspection procedure. STICK TO IT.

DO remove all inspection plates and cowlings in the area to be inspected.

DO clean all items to be inspected. This is essential in order to clearly see the parts you are inspecting. Inspect before and after cleaning.

DO check all moving parts for proper lubrication and check the "jam" or locking nuts on push-pull controls or adjustment devices for security.

DO familiarize yourself with proper safetying techniques and inspect for proper safetying. Resafety a part you have unsafetied before inspecting the next item.

DO seek assistance in any questionable area. A certificated mechanic, an approved repair station, or your local FAA inspector are your prime contacts. Use them.

DO the job right the first time—save a life—it may be your OWN.

DON'TS

DON'T be hurried—take plenty of time to properly inspect each item. If you don't know what to do next, ASK.

DON'T move the propeller unless the magneto switch reads "OFF," or the ignition system is otherwise rendered inoperative.

DON'T presume an item is airworthy until it has been checked.

DON'T check landing gear by kicking it—raise it off the ground.

DON'T perform any complex inspection or maintenance operation unless you are properly supervised by a certificated mechanic.

DON'T take the attitude—it can't happen to me.